MANUFACTURING THE VIXEN FILE*

METHODS USED IN PRODUCING A CIRCULAR CUT FILE

BY CHESTER L. LUCAS†

Since the days when primitive man used the file for sharpening his implements of field and war, the file has been one of the most common tools. As in many other commonplace things, however, no one seemed to see room for improvement until, in 1900, Alexis Vernaz, of Yverdon, Switzerland, was trying to devise a hand tool for cutting a lot of exceptionally hard castings. The Vixen file was the result of his efforts. His whereabouts is not known at present, but there is an Elliott Cresson medal waiting for him that was awarded by the Franklin Institute in 1909 for making the first radical improvement in files for generations. The essential points of the Vixen file are well described by a sentence from the patent specifications: "A file provided with teeth cut in the form of arcs, having their bases located rearwardly with respect to the cutting edge of the teeth."

Fig. 1 illustrates a Vixen file, in which it will be seen that the radical difference between it and the ordinary file lies in the shape of the teeth. The object of curving the teeth is to provide a shearing cut, and by reason of this shearing cut

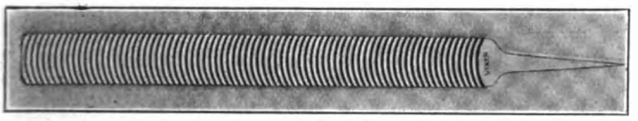

Fig. 1. The Vixen File

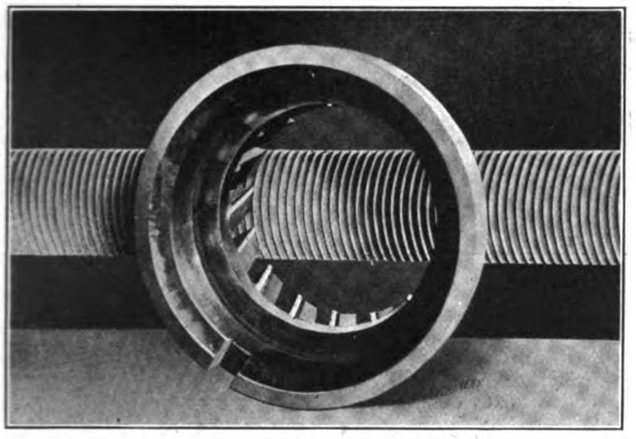

Fig. 2. How the Teeth are cut on Vixen Files

the file is self-clearing. The determination of the radii of the arcs of the cutting teeth of the various sizes of files was the result of experiments which indicate that the best cutting tooth is obtained by using a radius approximately the width of file being made. Teeth cut on smaller radii in proportion to the width of the file make it impossible to guide the file correctly, and teeth of much larger radii do not cut nor clear as easily. The teeth of Vixen files are milled with hollow cylindrical cutters. Several of these cutters are shown in

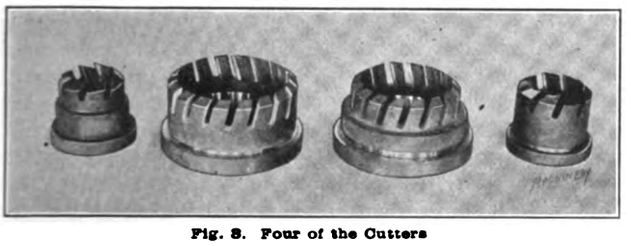

Fig. 3. Four of the Cutters

Fig. 3. Of necessity, the cutter is slightly inclined to the face of the file while cutting the teeth, in order that the side of the cylindrical cutter not being used may clear the parts of the file not being cut. This condition is graphically shown in Fig. 2. The amount of this inclination varies from 2 to 4 degrees, depending on the different depths of cut. By thus inclining the cutter to the work and securing a rake to the teeth, an added quality is given to the tooth, enabling it to cut rapidly. The inclination of the axis of the cutter results in cutting the teeth slightly deeper at the center than at the edges, therefore, the face of the finished file is slightly lower

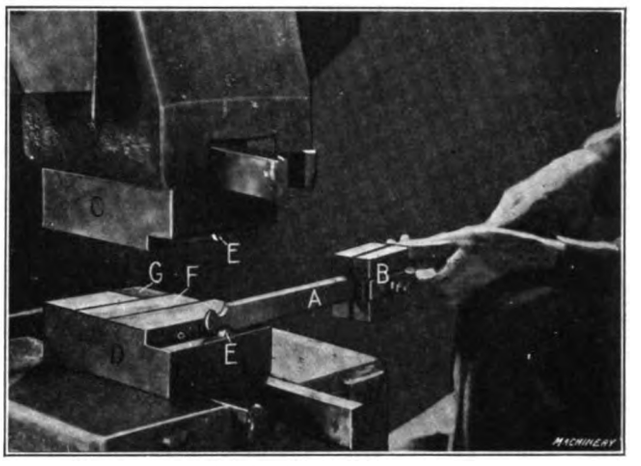

Fig. 4. Forging the Tang

in the center, the amount, however, is so small that it is practically imperceptible.

Steel for Vixen Files

The steel from which Vixen files are made is a Swedish chrome steel and is ordered on specification calling for chemical analysis as follows:

Carbon	1.20 to 1.35 per cent (1.25 per cent desired)
Chromium	0.40 to 0.60 per cent (0.50 per cent desired)
Manganese	not to exceed 0.40 per cent
Silicon	not to exceed 0.30 per cent
Phosphorus	not to exceed 0.03 per cent
Sulphur	not to exceed 0.03 per cent

The hardness, according to the Brinell hardness scale, should be from 130 to 170, a hardness of 150 being desired.

Operations in Making the File

The first operation in the making of the file consists in the shearing of the bar stock to length. This is an

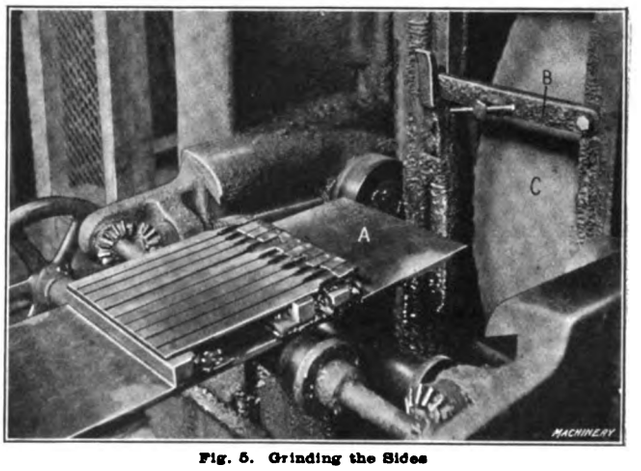

Fig. 5. Grinding the Sides

ordinary operation and is performed upon a shearing press of the usual type. From the shearing press the short lengths of steel go to the tanging hammer where the tangs of the files are forged in the manner illustrated in Fig. 4. The dies, and the beginning of the tanging operation are here illustrated. A helper hands the file blank, one end of which has been heated to a forging heat, to the operator of the hammer in which the tangs are forged. The blank *A* is held in special tongs *B*. The first part of the tanging operation consists in "nicking" the end of the file blank between the two half rounded projections *E* at the front of the dies *C* and *D*, leaving

* For further information on file making, see the following articles in MACHINERY: "File Making at a Sheffield Works," April, 1911, engineering edition; "Toolmakers' Files," January, 1911; "Vernaz Circular Cut File," October, 1909; "Making Swiss Files in America," September and October, 1907. See also MACHINERY'S Reference Book No. 48, "Files and Filing."

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the file blank in the condition shown. After this blow the operator shifts the file blank to the middle section *F* of the dies which have beveled faces corresponding with the taper of the tang. By rapidly turning the blank after each blow, the metal beyond the nicked portion of the blank is drawn out to approximately the shape of the finished tang, after which one or two blows are struck on the finishing faces *G* of the die to complete the tang. It is an almost incredible fact that the tang of an 8-inch file is forged in from ten to fifteen seconds from the time it is taken from the fire.

Following the tanging operation, the trademark impression is stamped upon the shank of the file, after which the blanks are annealed by being heated in large quantities in iron boxes and allowed to cool very gradually. The annealing operation decarbonizes the exterior surface of the steel, and before cutting the teeth it is important that this inferior surface of the stock be faced off. This operation, called stripping, is common in making files of all kinds, the metal being removed on large broad-faced grindstones, six feet in diameter. The files are held by the tangs on the plate shown at *A* in the illustration

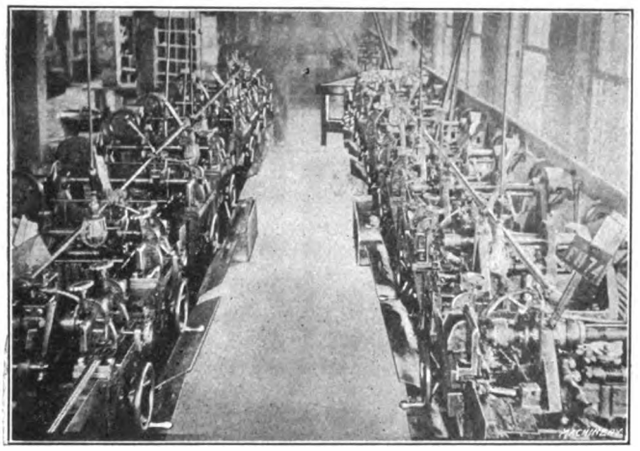

Fig. 6. Two Groups of the Tooth-milling Machines

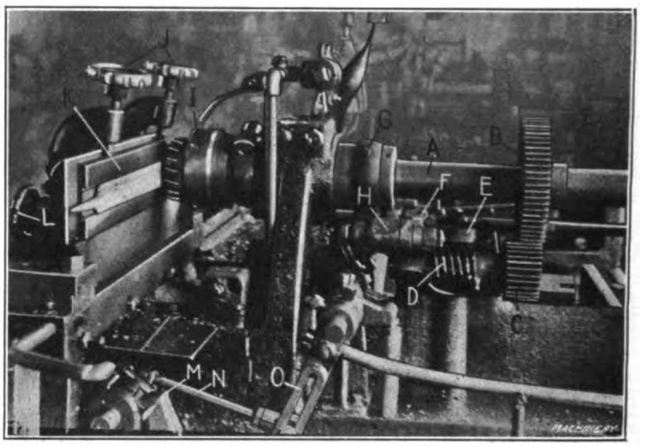

Fig. 7. Details of Machine for Milling Teeth

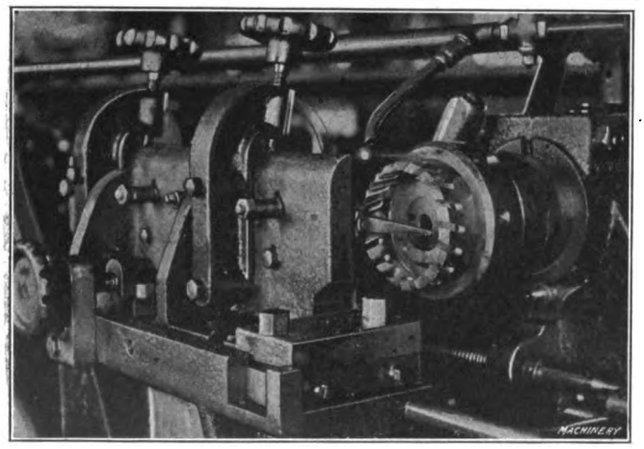

Fig. 8. Close Range View of Cutting Head

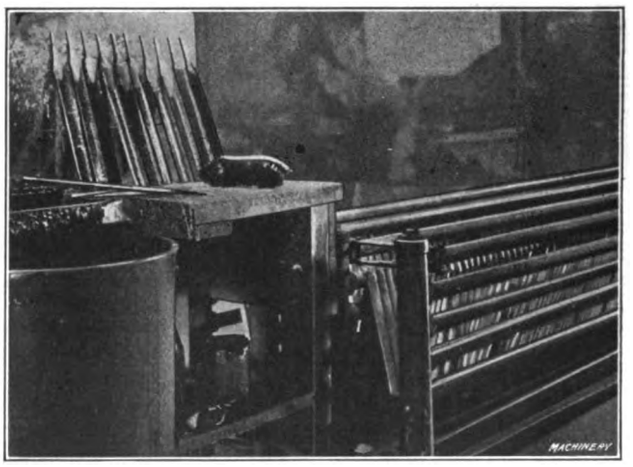

Fig. 9. Preparing the Files for heating in the Lead Bath

Fig. 5, which is dropped into position against the wheel and clamped by bar *B*, after which the holding plate and files are reciprocated in a vertical line against the face of the wheel *C*, at the same time being flooded with water and fed gradually against the wheel. By this means, 1/64 inch is removed from each side of the file-blanks, leaving them perfectly flat and ready for the cutting of the teeth.

Cutting the Teeth

The most interesting operation in connection with the making of the Vixen file is the cutting of the teeth. The machines for cutting the teeth are operated in groups of eight, being driven from lineshafting at the rear of the rows of machines. Two of these groups of machines are shown in Fig. 6. The machine consists essentially of a spindle which carries the cylindrical cutter and a table which supports the file blank in a plane at right angles to that of the cutter spindle. As the cutter revolves, it is fed forward to the file blank, withdrawn, the file holding table moved forward the distance of one tooth and the cutter spindle brought forward again. Thus, the teeth are cut one at a time and the machine is automatically stopped after the last cut. Referring to Fig. 7, the cutter spindle, its method of feeding and the cross feed of the work table, may be seen. The cutter spindle shown at *A* is driven by bevel gearing from the extreme right-hand end of the machine. By means of gear *B* in mesh with gear *C* operating on a worm-shaft, the worm *D* engages a worm-wheel, not shown, which causes cam *E* to turn against yoke *F*. Yoke *F* is attached to collar *G*, and thus as the high part of the cam is reached, the cutter is fed forward to its deepest position with respect to the file and, of course, returned when the low part of the cam is reached. The double spring box *H* constitutes a means for insuring the feeding of the cutter to the proper depth of the tooth in each instance; the springs within the barrels overcoming any tendency for uneven feeding of the spindle caused by chips lodging upon the cam or from other sources.

The cutters themselves are made of Rex high-speed steel. Four of these cutters are shown in Fig. 3, and, as may be seen, they are milled very deep between the teeth, which allows them to clear themselves of chips rapidly and provides for many sharpenings before they are worn out. The cutting faces are ground to an included angle of 60 degrees and the cutter is held to the end of the spindle by a flanged sleeve *I*, shown in Fig. 7, which is tightened by a spanner wrench holding the cutter securely in place. The illustration Fig. 7 also shows the method in which the files are held for cutting, consisting of the two clamping screws *J* which operate against jaw *K* of the vise. For varying the depth of the tooth, handwheel *L* is used, thereby bringing the work table nearer to or farther from the cutter. The number of teeth cut per inch varies from 6 2/3 to 16, and for spacing the teeth there is a ratchet and pawl upon the end of the feed shaft. This pawl, shown at *M* in the illustration Fig. 7, is operated by a lever *N* which, in turn, is reciprocated by the arm *O*. Another view of this machine is shown in Fig. 8 which more clearly shows the cutter and its relation to the file blank.

The widths of the files vary from 7/8 inch to 1¾ inch.

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There are, on each side, from 90 to 250 teeth, varying, of course, with the pitch and length of the file. It takes twenty-five minutes to cut the teeth in one side of an ordinary 12-inch Vixen file, as compared with one minute for cutting the teeth on one side of an ordinary commercial 12-inch file. Hence it is apparent that the manufacturing cost of a Vixen file is comparatively high.

Hardening

Previous to heating the files for hardening, they are treated with a charcoal and oil preparation to prevent the lead used in the heating from clinging to the teeth and thus interfering with the hardening. The files are brushed with this solution and placed against racks of steam pipes as shown in Fig. 9, to bake the coating on before the files are placed in the lead pot.

The molten lead in which the files are heated is kept at a temperature of 1400 degrees, its condition being indicated by a Bristol pyrometer. Several files are kept heating in the lead pot, being immersed to the tangs. A bar across the top of the lead pot holds the files beneath the surface of the

Fig. 10. The Cold-straightening Operation

molten lead so that they may be heated slowly and evenly. A file is taken from the lead pot by the hardener, and before being quenched in the brine solution in which the files are hardened, the red hot file is rapidly straightened across lead blocks with a wooden faced hammer. This operation, which is shown in Fig. 11, is necessary on account of the strains set up in the steel by the milling of the teeth. After straightening, which takes but a few seconds, the file is plunged straight down into the brine and moved rapidly up and down until the "singing" has nearly ceased. The file is then quickly removed, sighted, and again straightened after the manner shown in Fig. 10. For this purpose the file is clasped in an iron holder, *A*, after sighting, and placed with the high side down against the wooden bar *B*, the tip end of the file being caught under bar *C*. Pressure is then applied to straighten the file and cold water splashed upon the upper side to bring the file back to a straight condition. This operation of straightening requires a great deal of judgment, for, if the file is kept in the hardening tank a few seconds too long, it will break when pressure is applied for straightening, and on the other hand if removed too quickly, the temper of the file will be impaired.

Sharpening the Files

From the hardening department the files go directly to the sharpening machines. Unlike the sharpening of most tools, files are sharpened by being passed over jets of steam which is mixed with a cutting paste made with a fine mineral abrasive powder. The sharpening machine shown in Fig. 13 is equipped with three nozzles which are shown being used

Fig. 11. Straightening Hot Files

in the operation of sharpening Vixen files. The base of the machine contains the sharpening paste which is led to the nozzles of the steam pipes and thus is propelled against the sides of the file when it is moved backward and forward over the nozzle. A spool, shown just above the nozzle, is used to keep the file at the proper distance from the nozzle. In

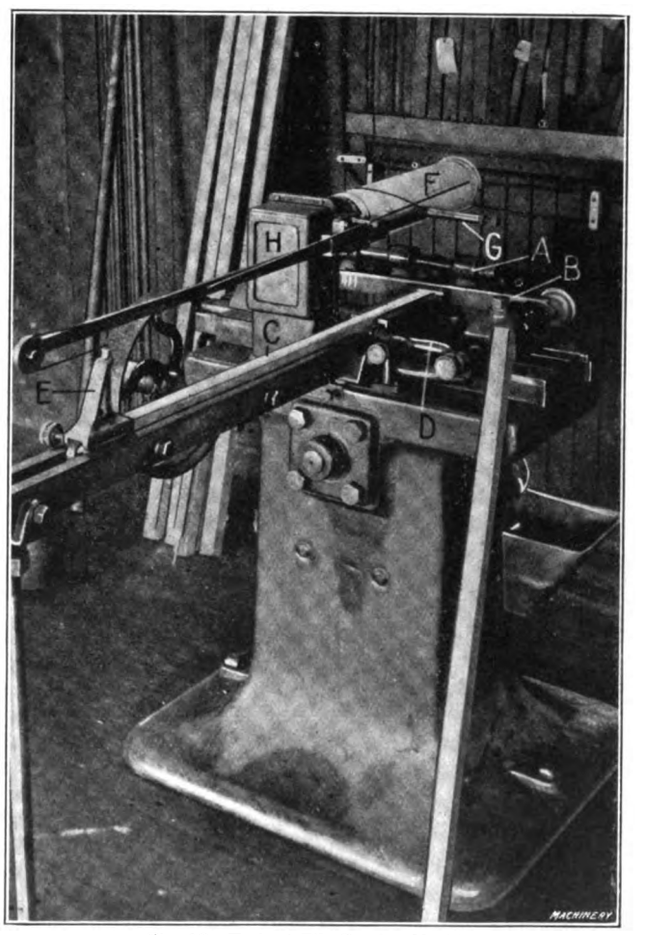

Fig. 12. Herbert File Testing Machine

addition to removing all dirt and scale from the files, this operation sharpens the file by cutting away a slight amount from all parts of the file which it strikes. The files are held by the tangs and in passing over the nozzles, the abrasive material strikes the teeth from the back. If the operation were reversed and the files fed in from the points, the sharpness of the teeth would be removed and the files dulled instead of sharpened. For testing the sharpening, "provers"

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are used. These provers consist of short pieces of soft steel which are drawn over the file by hand. Even to those unaccustomed to this work, the prover indicates the fact that the file has been really sharpened, and to the sharpener the prover reveals any sections of the file which are not quite up to standard sharpness. Lime is added to the special sharpening compound to prevent the files from rusting after they leave the sharpening machine. The final operation consists in cleaning out the file under a jet of live steam, and after oiling, the files are ready for use.

Testing Files on the Herbert File Testing Machine

A Herbert file testing machine, shown in Fig. 12, the working parts of which are shown in detail in Fig. 14, forms the

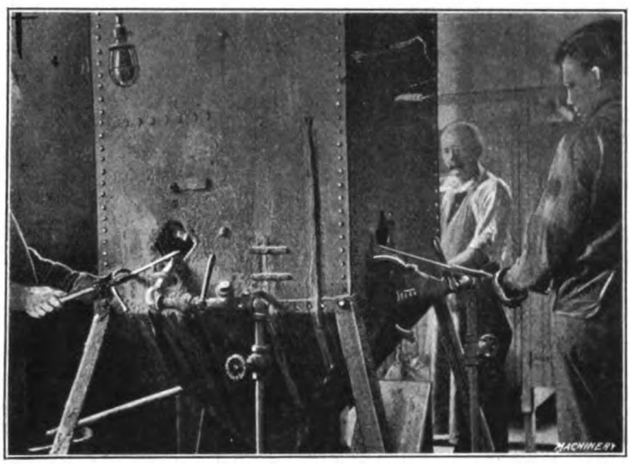

Fig. 13. Sharpening the Files

only practical method of testing the cutting and enduring qualities of the file. This machine was described in detail in MACHINERY, December, 1907, and is also described in MACHINERY'S Reference Book No. 48, "Files and Filing." Briefly stated, the machine consists of a reciprocating file holder *A* in which the file *B* is held, backed up by suitable supports. The file is reciprocated across the end of the square test bar *C* at the rate of 50 strokes per minute. On the return stroke, the bar is withdrawn slightly by means of arm

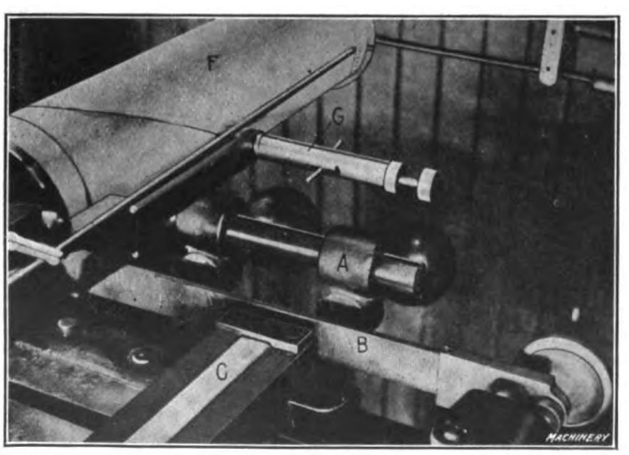

Fig. 14. Details of the File Testing Machine

D. The forward feeding of the bar is accomplished by means of a 30-pound weight which is attached to the bar at the front of the machine by a chain running over a pulley. The rate of forward travel of the bar is recorded on the chart *F*, by the pencil held in the holder *G*. By means of clockwork within the case *H*, the chart cylinder is turned slowly, with the result that a curve is traced upon the chart which indicates the cutting efficiency of the file tested.

Credit is due to Mr. W. D. Craft, manager, and Mr. C. M. Zubler, superintendent of the Vixen Tool Co., Philadelphia, Pa., for courtesies shown the writer in the preparation of this article.

* * *

Muzzling the gears may not stop them from biting, but it promises to muffle the bark.

MAKING THE FOSTER SAFETY SET-SCREW

BY CHESTER L. LUCAS*

In the new factory of the New Haven Machine Screw Co., New Haven, Conn., which appears in Fig. 1, a considerable part of the work consists in the making of the Foster safety set-screw. The factory is of reinforced concrete, and in designing the building, special attention was given to the lighting system; as may be seen, almost all of the wall space is taken up by windows. Fig. 2 shows a view of the automatic

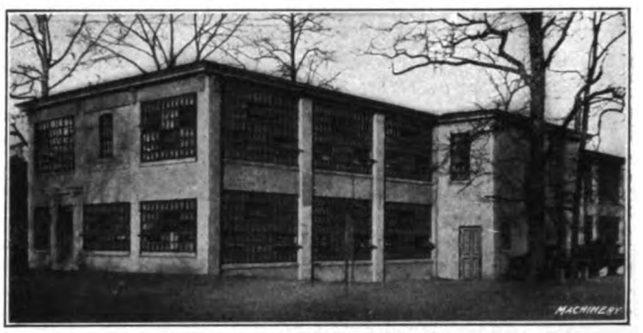

Fig. 1. Home of the Foster Safety Set-screw

turret lathe department in which the blanks for the set-screws are made. Low carbon steel is used in making the set-screws. The turret lathes used are of the multi-spindle type, operating on four bars of steel at once, and when the blanks are dropped from these machines they are in the condition shown at *A*, Fig. 3, having the point roughly shaped, the opposite end rounded, and the stock drilled from the central hole.

In the second operation the hole is broached to a hexagonal

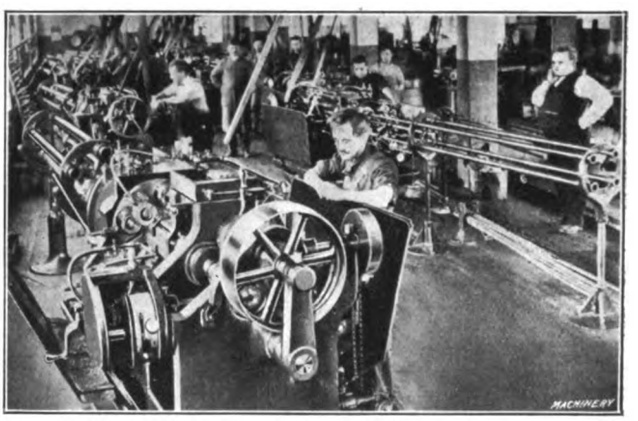

Fig. 2. The Automatic Turret Lathe Department

shape.† This operation is performed in a punch press, using the attachments shown in Fig. 4. Referring to this illustration, *A* is a dial revolving on a stud *B* which is fitted to the bed of the press. Around the edge of this dial, bushed holes are spaced to receive the set-screw blanks being broached. The dial is turned, bringing each of these holes successively under the broaching punch *C* by means of an indexing arrangement at the side of the press. This indexing arrange-

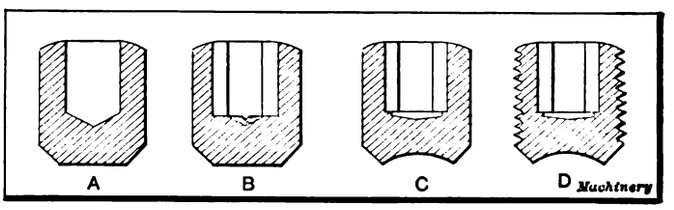

Fig. 3. The Four Steps followed in Making the Set-screws

ment consists of a lever *D* fulcrumed on the stud *E* and operated from the main shaft of the press. At the lower end of the lever, motion is transmitted to an arm *F* which reciprocates the indexing pawl *G* at each return stroke of the press ram. In broaching, the operator places the blanks in the holes in the revolving dial, and as they are indexed to the position under the punch, they are broached. Upon reach-

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† A method of progressively broaching square holes in socket wrenches was described in the March, 1902, number.

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